STATISTICAL DOWNSCALING:
IS PAST PERFORMANCE AN INDICATOR OF FUTURE RESULTS?

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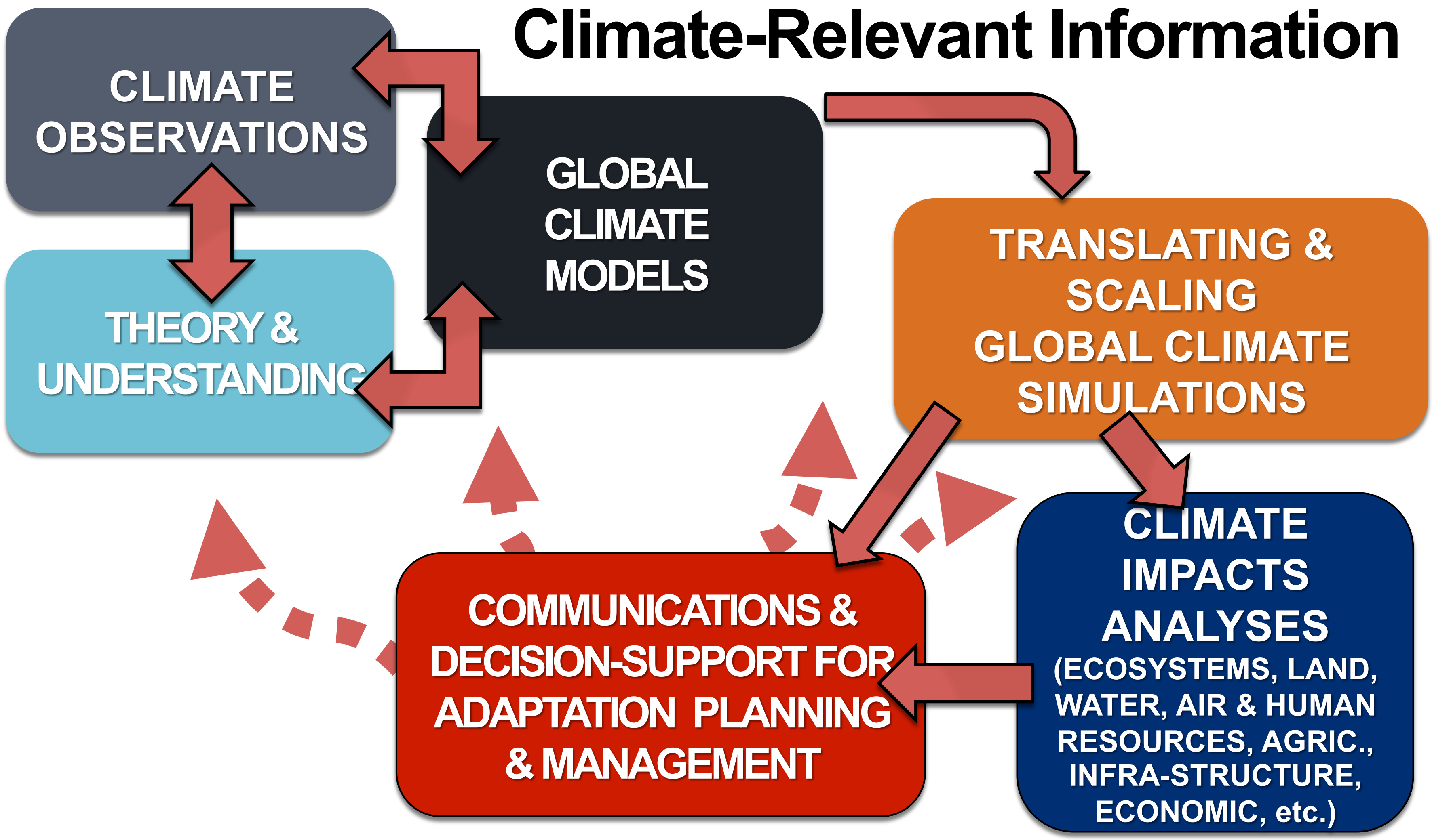
Understanding climate variability and change to enhance society's ability to plan and respond

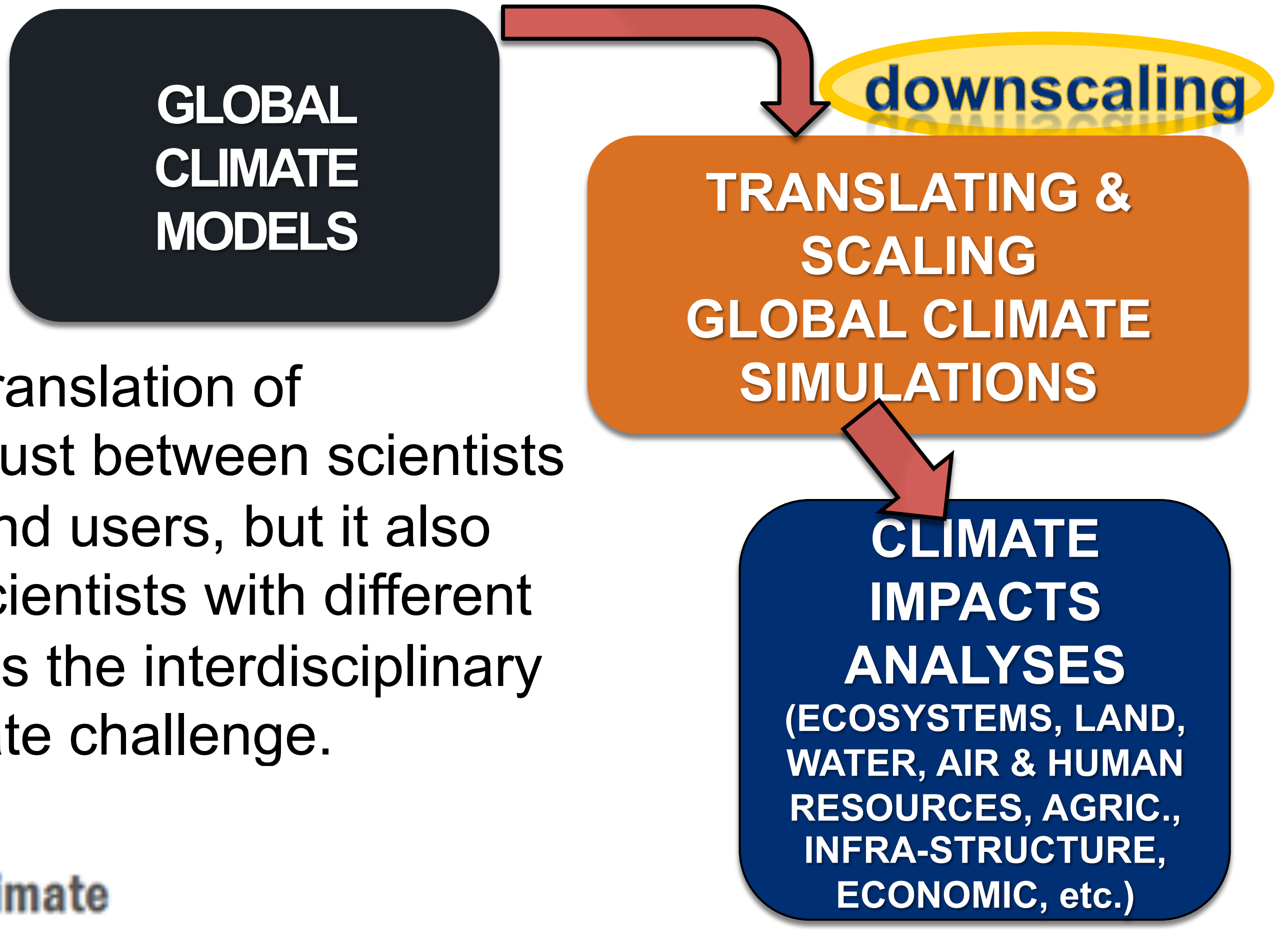
NCPP National Climate Predictions & Projections Platform

FROM SCIENCE TO STAKEHOLDERS

The Transfer & Translation of Climate-Relevant Information



The Transfer & Translation of Climate-Relevant Information



The transfer and translation of information is not just between scientists and the ultimate end users, but it also occurs between scientists with different specialties - such is the interdisciplinary nature of the climate challenge.

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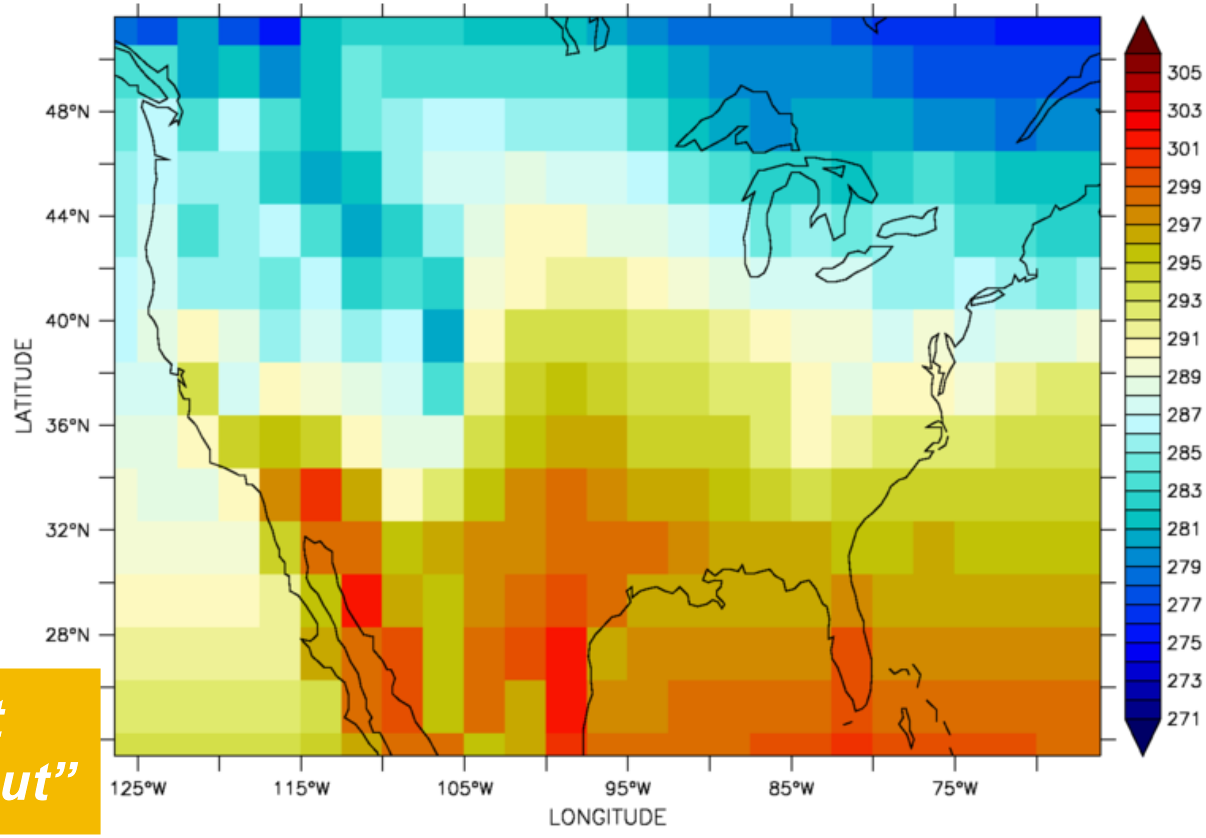
National Climate Predictions & Projections Platform

Why do statistical downscaling?

(aka **ESD**: empirical statistical downscaling)

"statistical refinement of dynamical model output"



Annual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 DEC 2008)

Common expectations for statistically downscale climate projections:

(a) Statistical downscaling adds realistic, finer-scale detail not found in the coarser resolution global climate models (GCMs).

(b) Statistical downscaling aims to correct for GCM biases and other shortcomings in the simulated distribution of climate variables of interest.

Why do statistical downscaling?

(aka **ESD**: empirical statistical downscaling)

ESD: Somewhat analogous to the MOS

Instead of maintaining a dynamic climate model at higher resolution, the statistical downscaling approach refines information from GCMs by using a series of empirically-derived equations to relate variations in large-scale climate to variations in local climate.

Adapted from www.southwestclimatechange.org/climate/modeling/downscaling

Assumed to be "value-added" product

Common expectations for statistically downscale climate projections:

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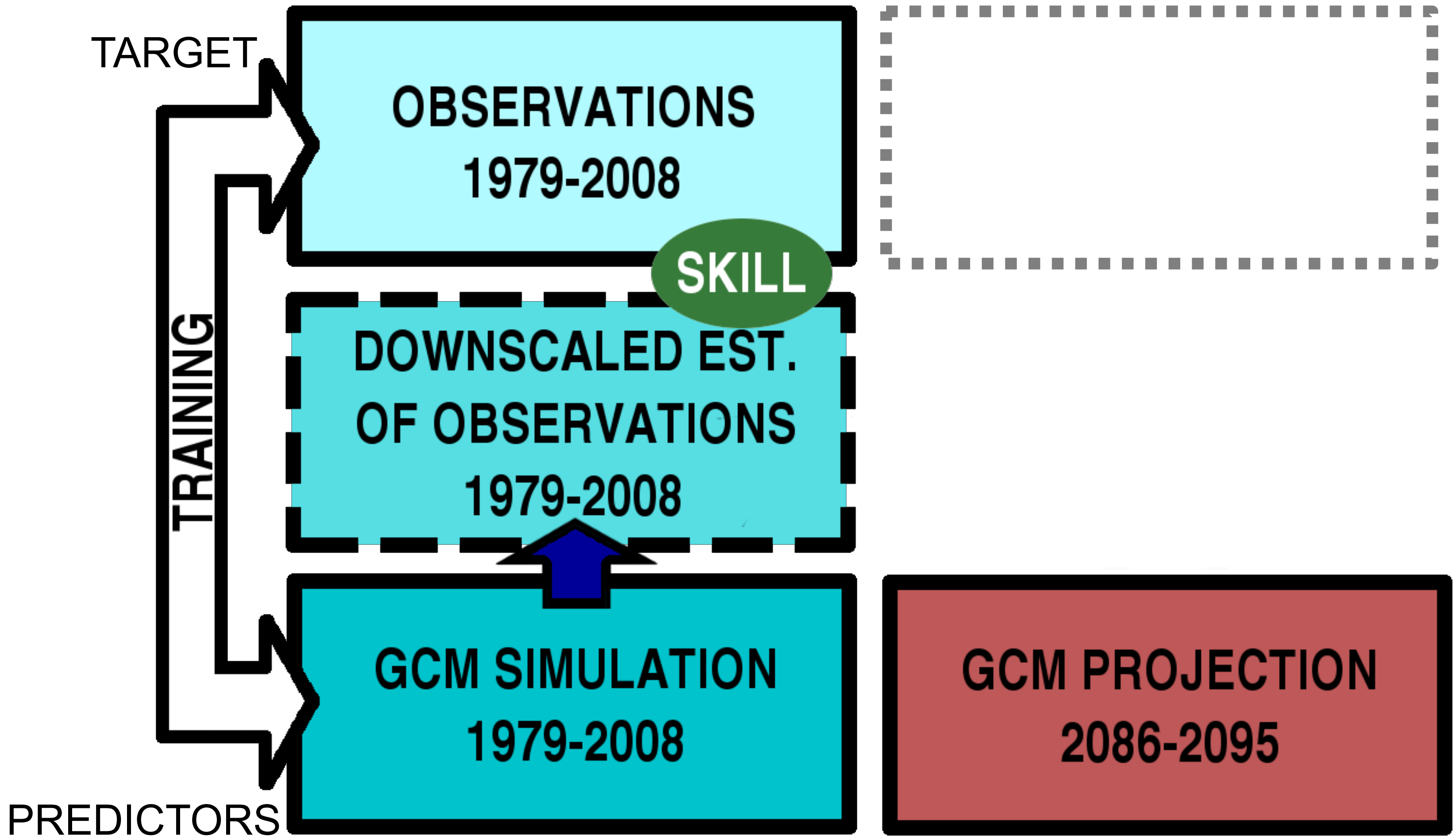
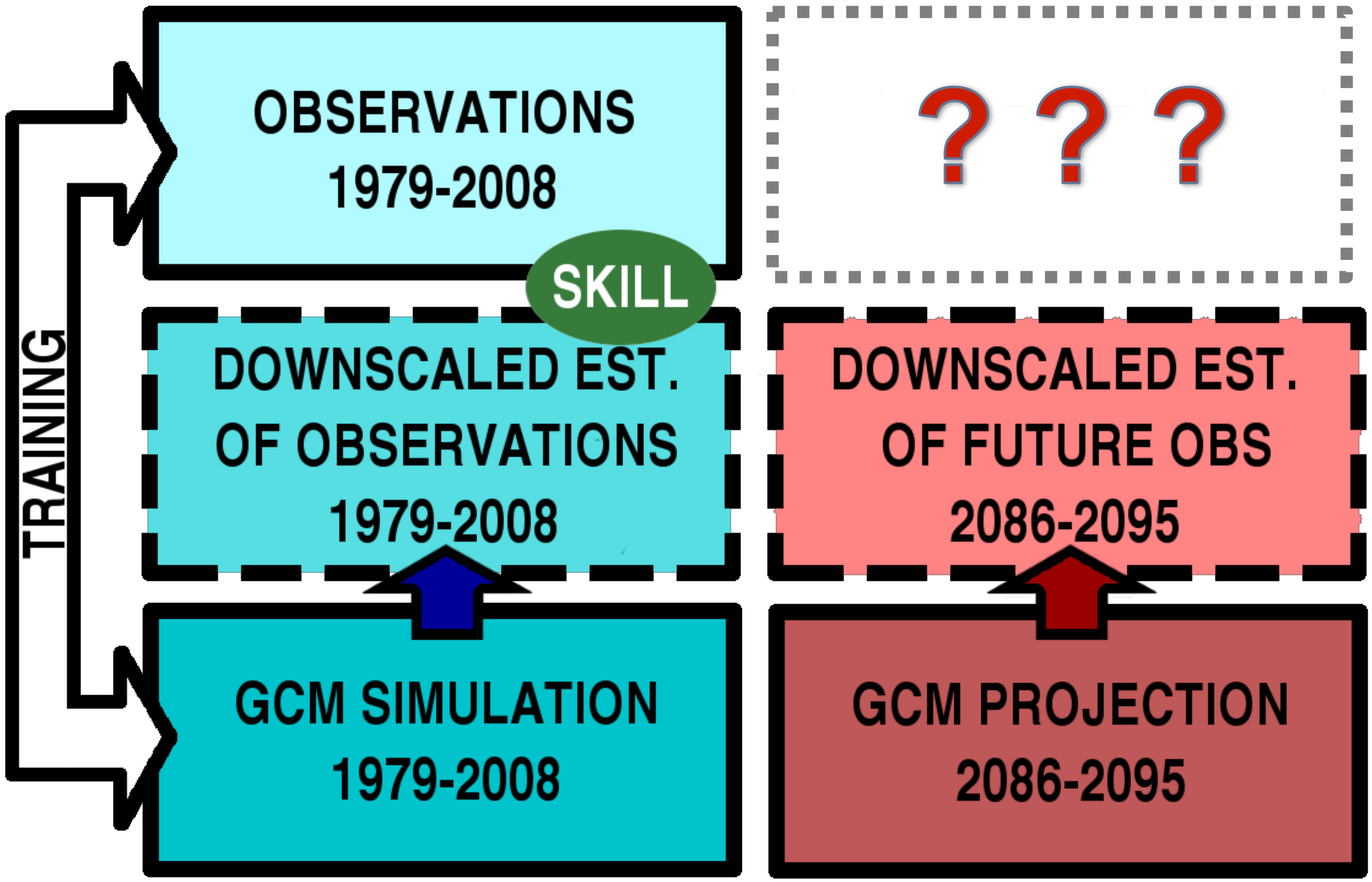
REAL WORLD APPLICATION:

Skill: Compare Obs to SD historical output (e.g., cross validation)



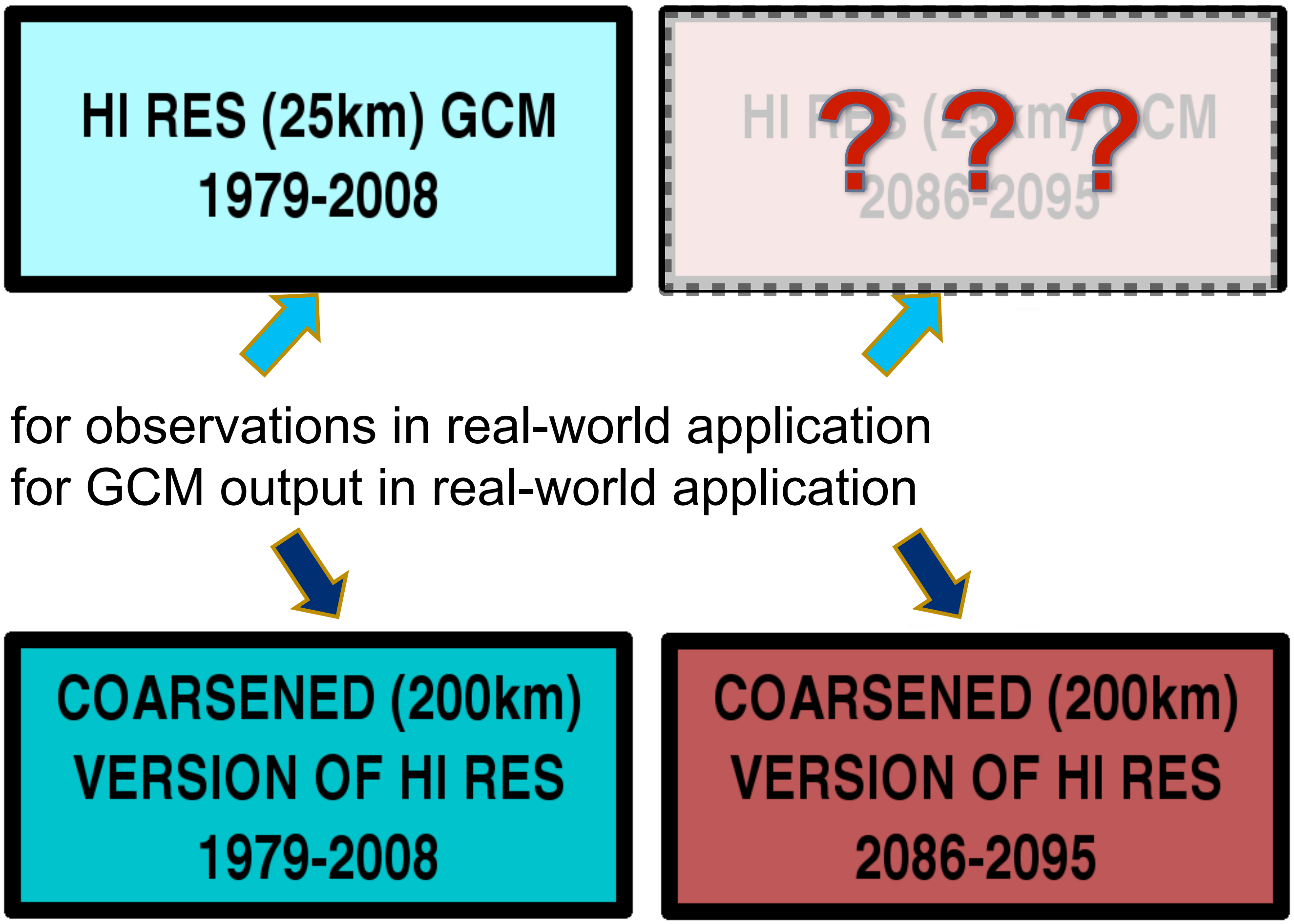
REAL WORLD APPLICATION:

Cannot evaluate future skill -- left assuming transform functions apply equally well to past & future -- **"The Stationarity Assumption"**

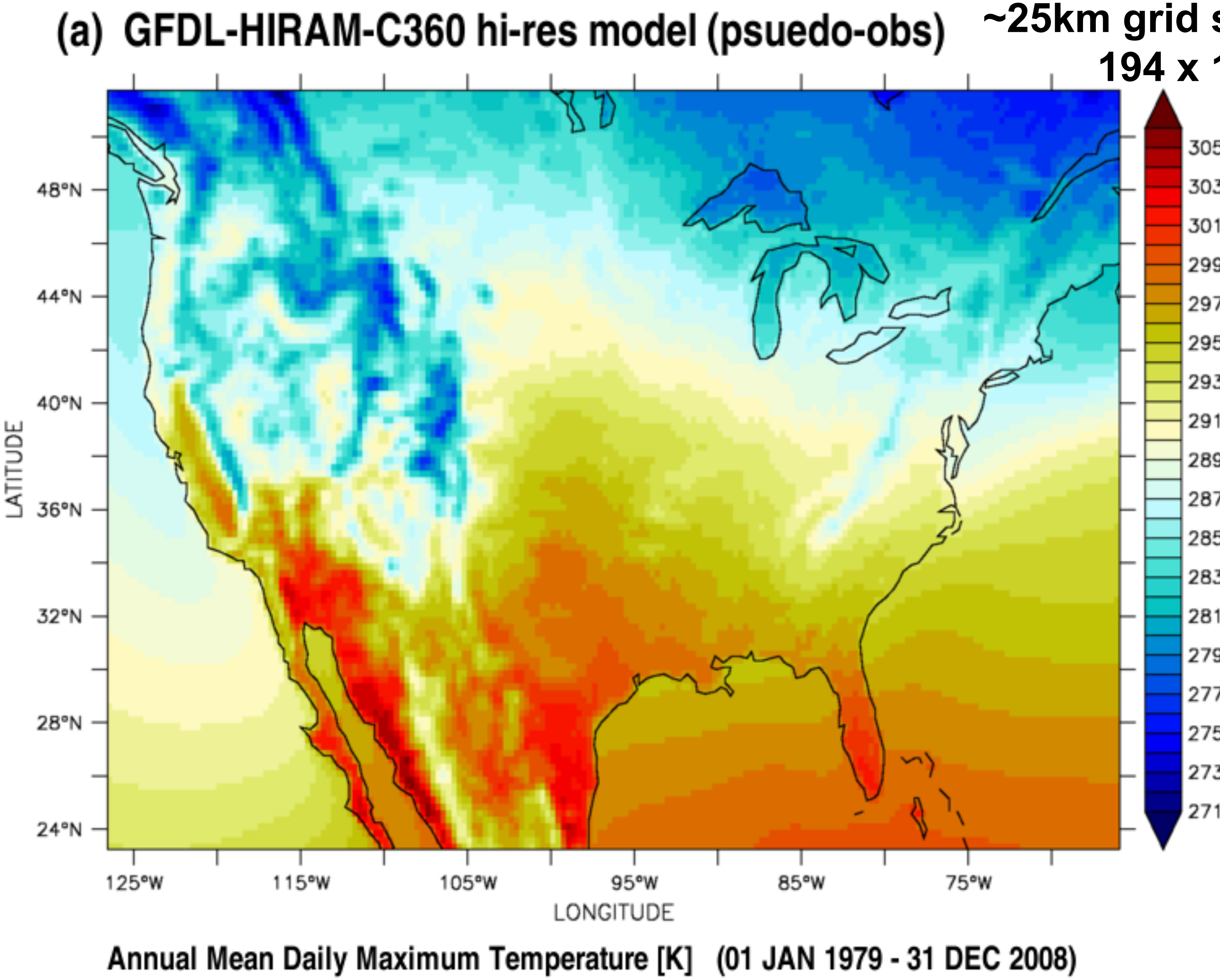


“PERFECT MODEL” EXPERIMENTAL DESIGN:

Start with 4 types of data sets – Hi-res GCM output as proxy for obs & coarsened version of Hi-res GCM output as proxy for usual GCM

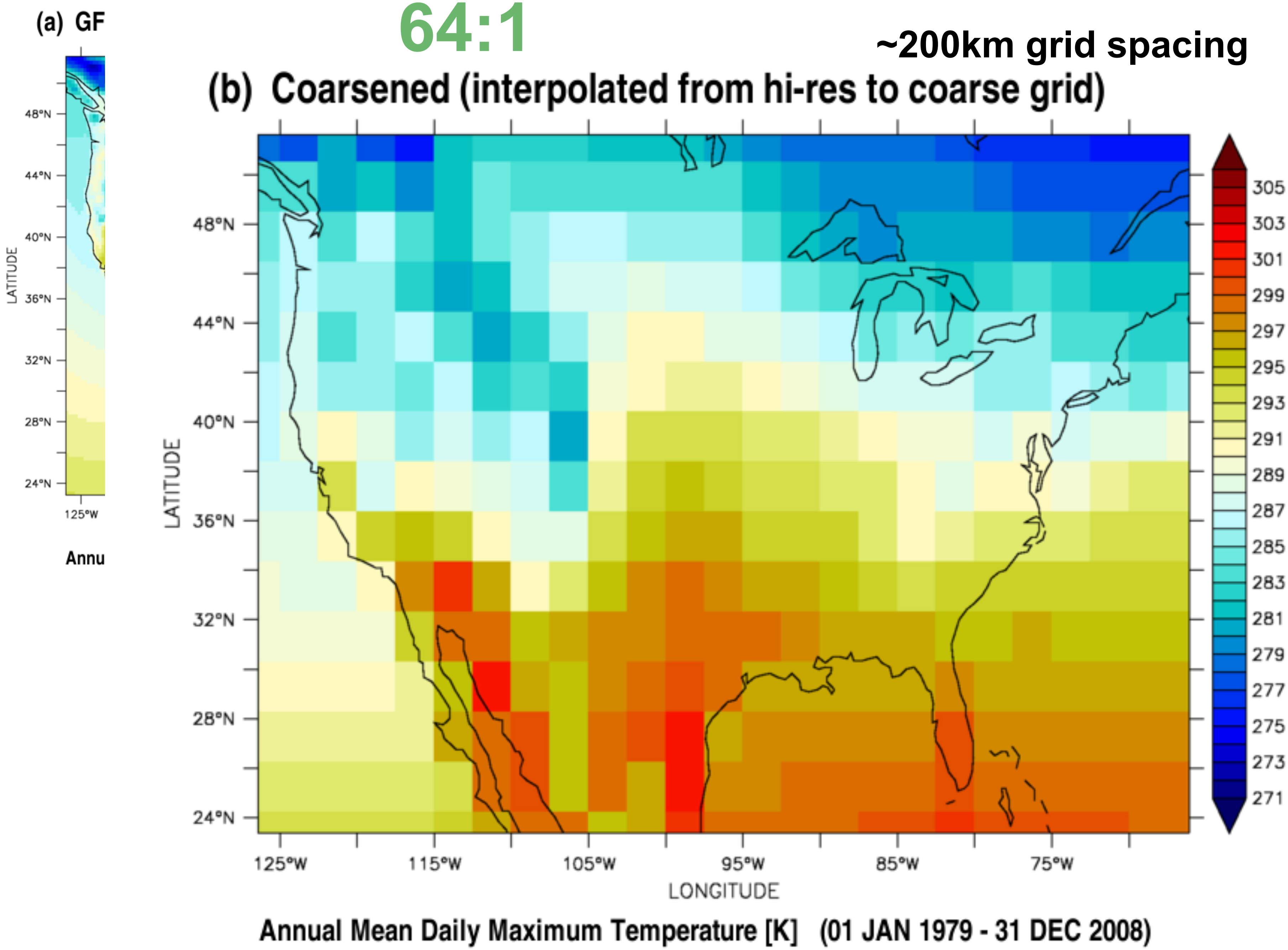


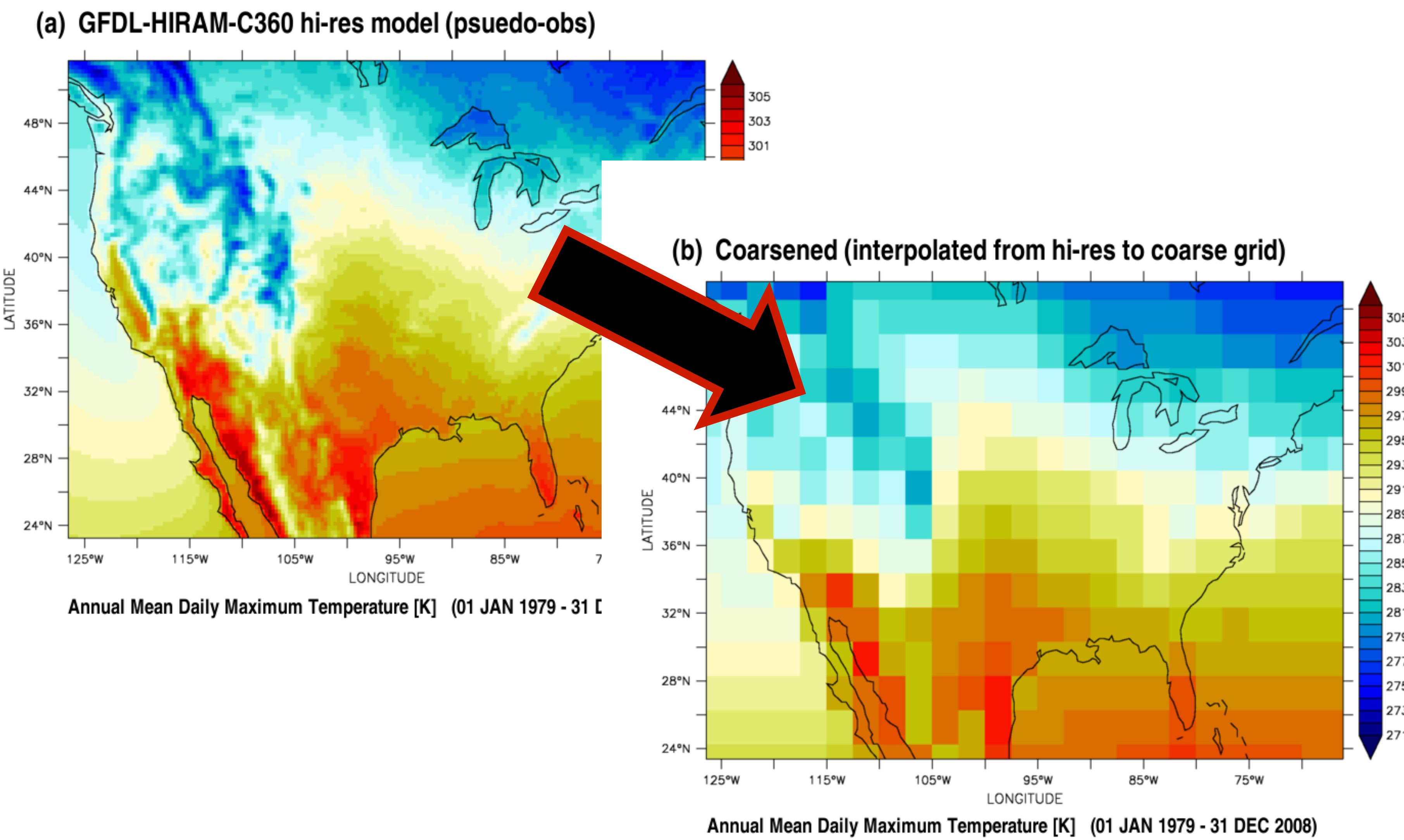
Daily time resolution
~25km grid spacing
194 x 114 grid
22k pts



64:1

~200km grid spacing




(a) GFDL-HIRAM-C360 hi-res model (psuedo-obs)
Annual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 D
(b) Coarsened (interpolated from hi-res to coarse grid)
Annual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 DEC 2008)
LATITUDE
LONGITUDE
48°N
44°N
40°N
36°N
32°N
28°N
24°N
125°W
115°W
105°W
95°W
85°W
75°W
305
303
301
299
297
295
293
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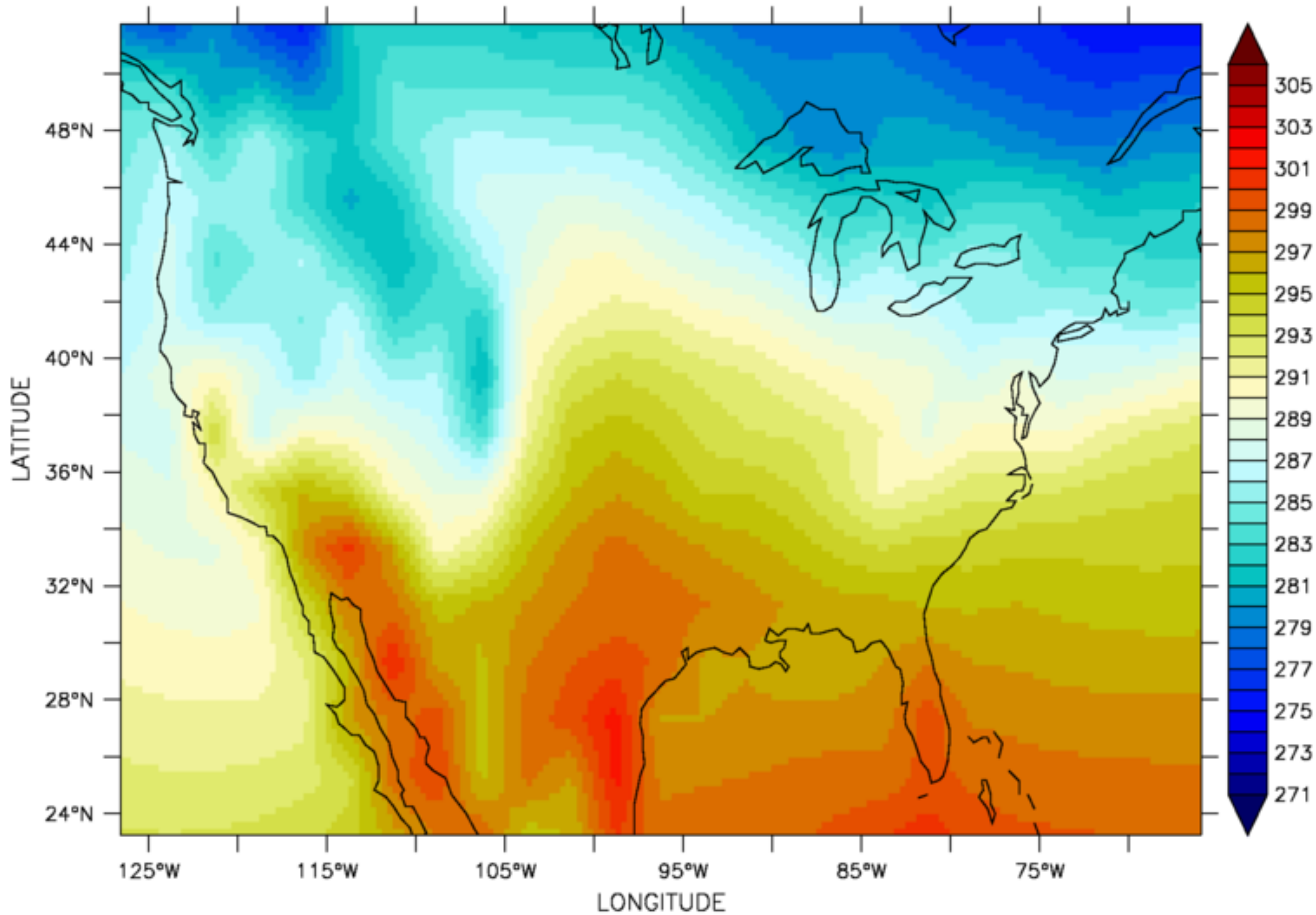
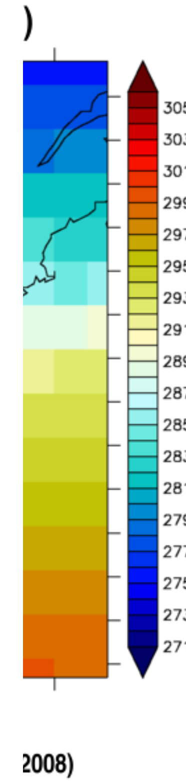
287
285
283
281
279
277
275
273
271

(a) GFDL-HIRAM-C360 hi-res model (psuedo-obs)

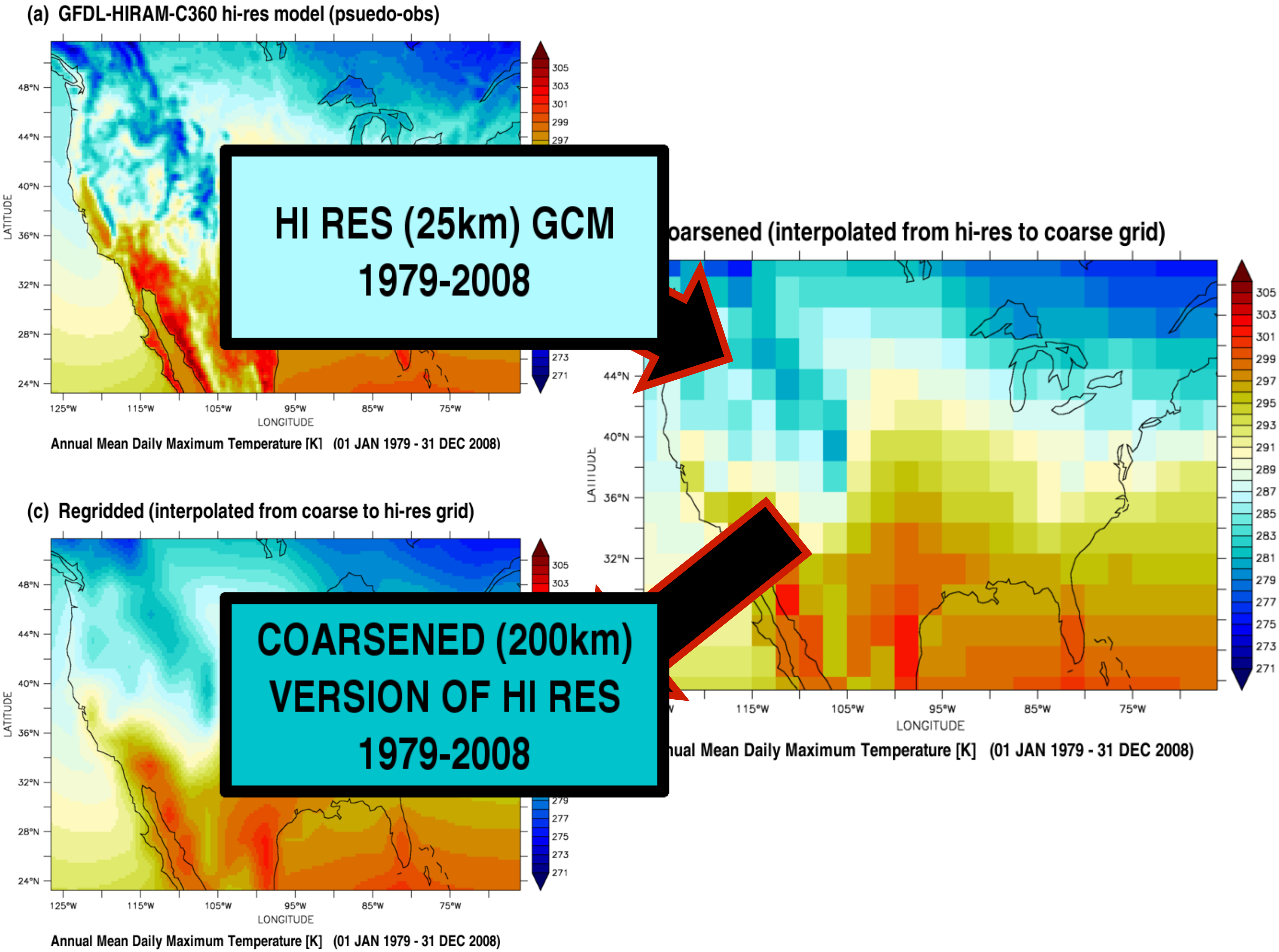
Daily time resolution
~25km grid spacing
194 x 114 grid

(c) Regridded (interpolated from coarse to hi-res grid)

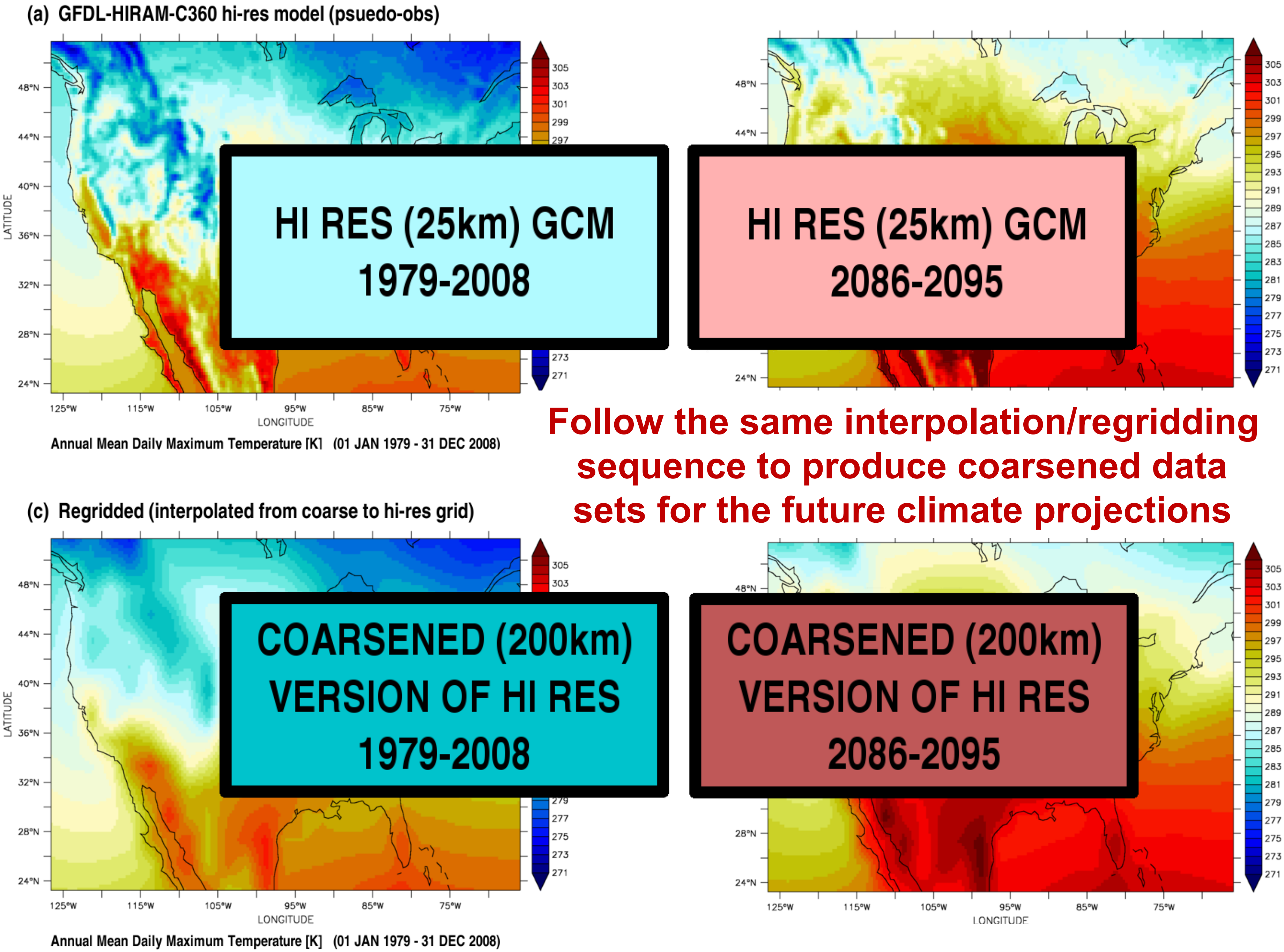




Annual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 DEC 2008)



(a) GFDL-HIRAM-C360 hi-res model (psuedo-obs)
Annual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 DEC 2008)
HI RES (25km) GCM
1979-2008
oarsened (interpolated from hi-res to coarse grid)
ual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 DEC 2008)
(c) Regridded (interpolated from coarse to hi-res grid)
Annual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 DEC 2008)
COARSENED (200km)
VERSION OF HI RES
1979-2008
LATITUDE
LONGITUDE


(a) GFDL-HIRAM-C360 hi-res model (psuedo-obs)
HI RES (25km) GCM
1979-2008
HI RES (25km) GCM
2086-2095
Follow the same interpolation/regridding sequence to produce coarsened data sets for the future climate projections
(c) Regridded (interpolated from coarse to hi-res grid)
COARSENED (200km)
VERSION OF HI RES
1979-2008
COARSENED (200km)
VERSION OF HI RES
2086-2095
LATITUDE
LONGITUDE
125°W
115°W
105°W
95°W
85°W
75°W
48°N
44°N
40°N
36°N
32°N
28°N
24°N
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Annual Mean Daily Maximum Temperature [K] (01 JAN 1979 - 31 DEC 2008)
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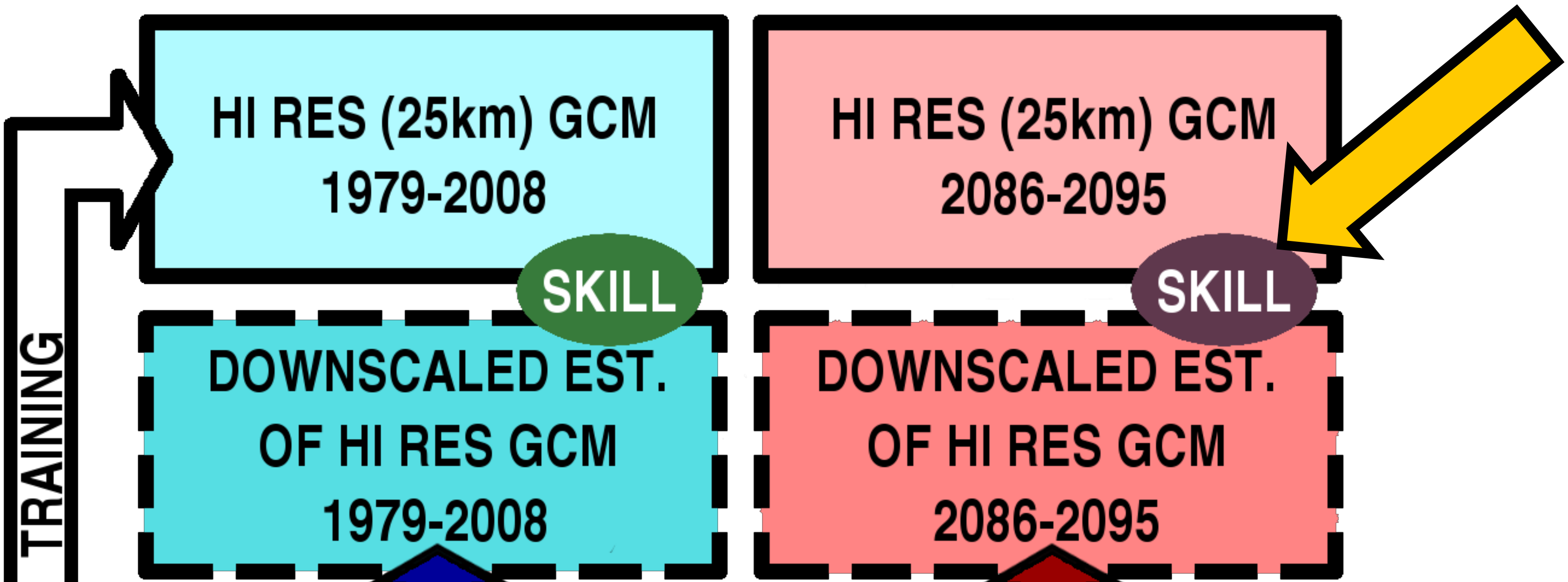
"PERFECT MODEL" EXPERIMENTAL DESIGN:

Can directly evaluate skill *both* for the historical period and the future using the Hi Res GCM output as "truth" – Test Stationarity



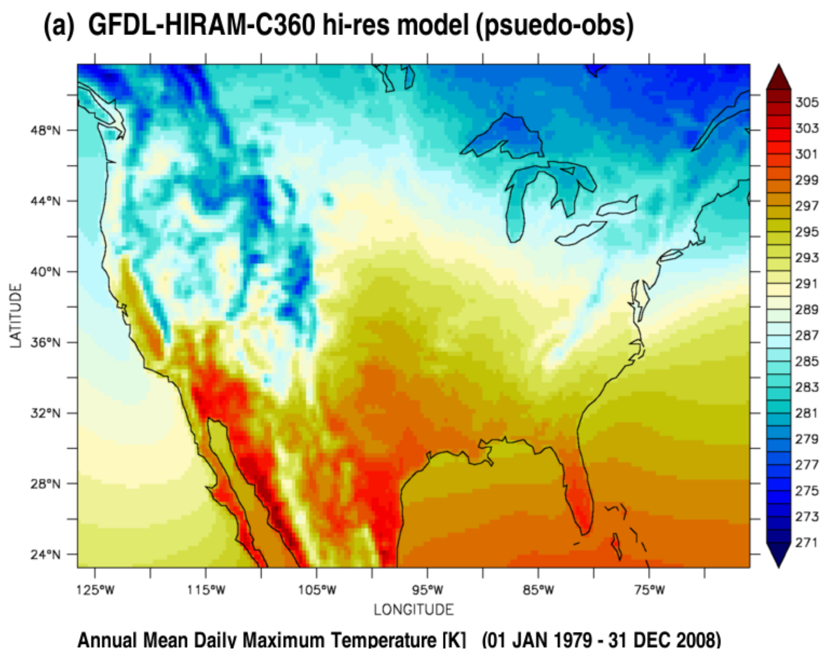
QuantitativeTests of Stationarity:

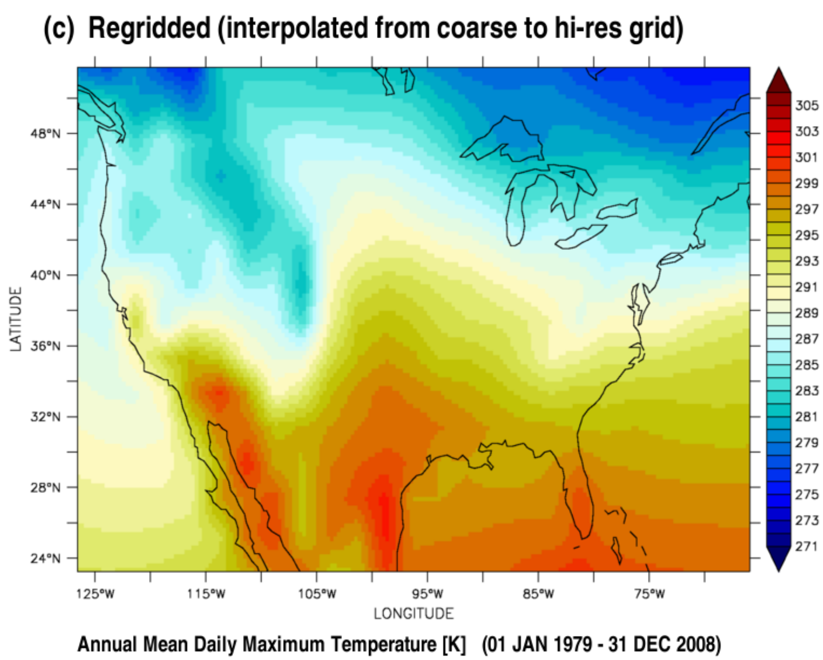
The extent to which

SKILL computed for the FUTURE CLIMATE PROJECTIONS

is diminished relative to the

SKILL computed for the HISTORICAL PERIOD





Q: How High a Hurdle does this Perfect Model approach present?

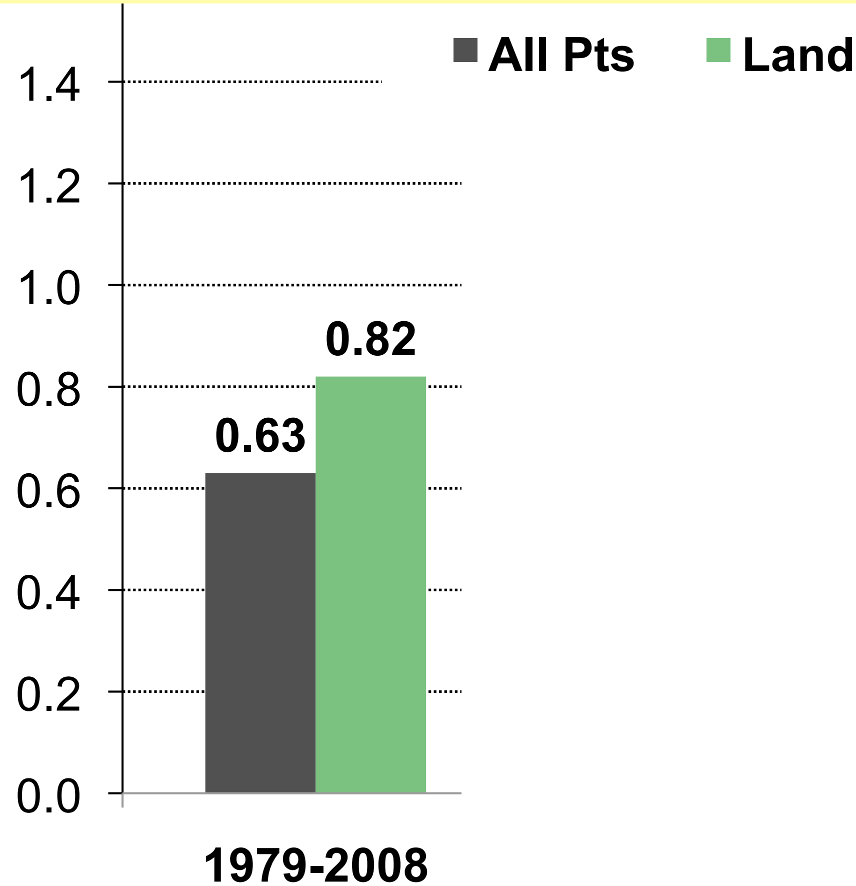
A: Varies geographically, by variable of interest, time period of interest, size of GCM-projected climate response, etc.

And it will vary among ESD techniques

NEXT: A sampling of results…

- Intended to be illustrative
  Not exhaustive, nor systematic.

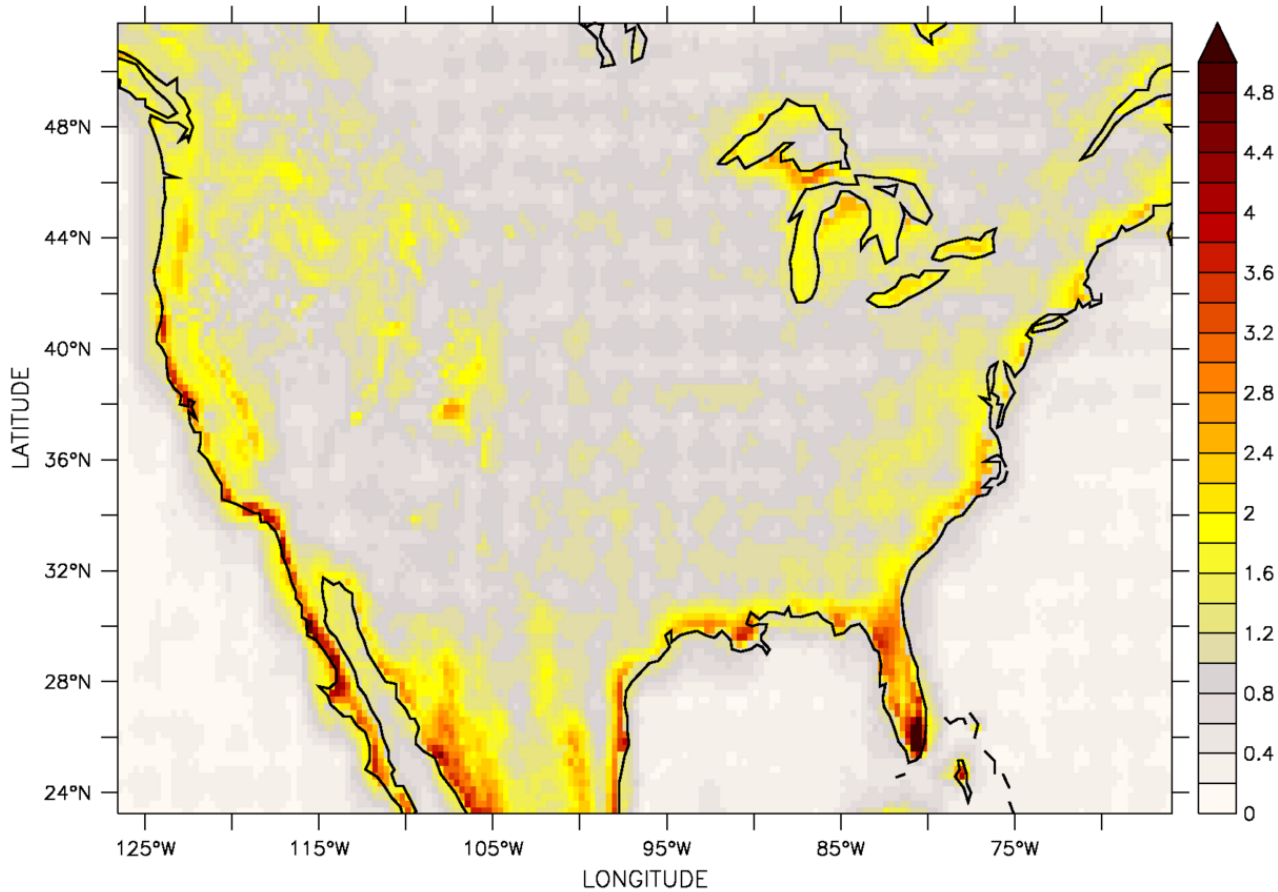
<u>Start with a summary:</u> ARRM downscaling errors are larger for daily max temp at end of 21stC than for 1979-2008



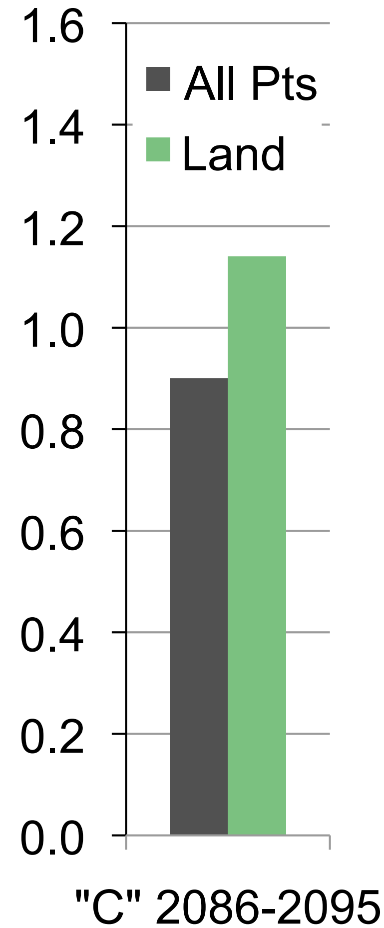
Area Mean Time Mean Absolute Downscaling Errors

$$\frac{\Sigma \; |\,(\text{Downscaled Estimate} \; - \; \text{HiRes GCM})\,|}{(\text{NumDays})}$$

<u>Geographic Variations:</u> MAE pattern for "C" projections (+7,6C)



mean absolute error Downscaled minus GCM: 2086–2095 CM3

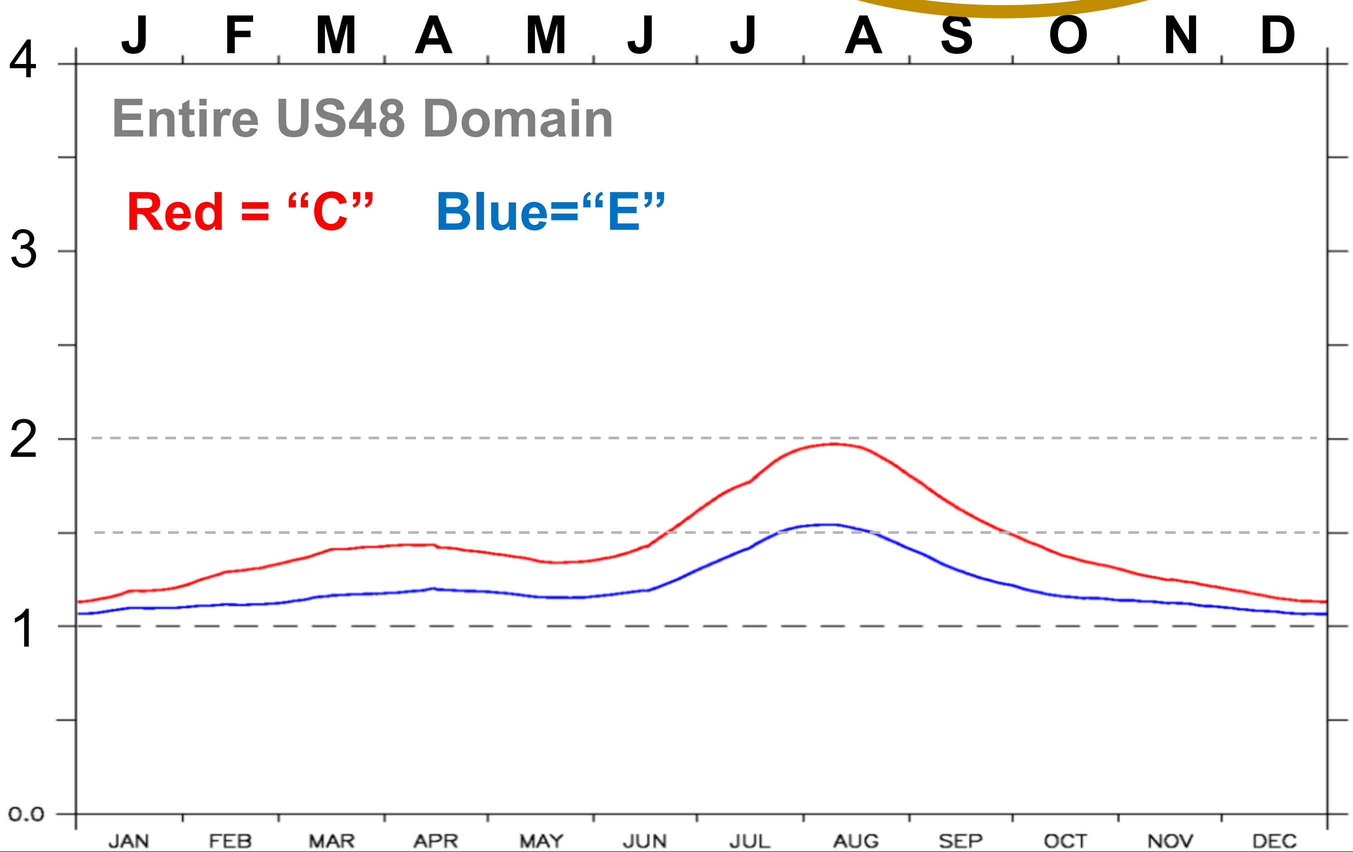


Mean absolute downscaling error during 2086-2095

"C" Projections (3 member ensemble)

Looking at how well the stationarity assumption holds in different seasons

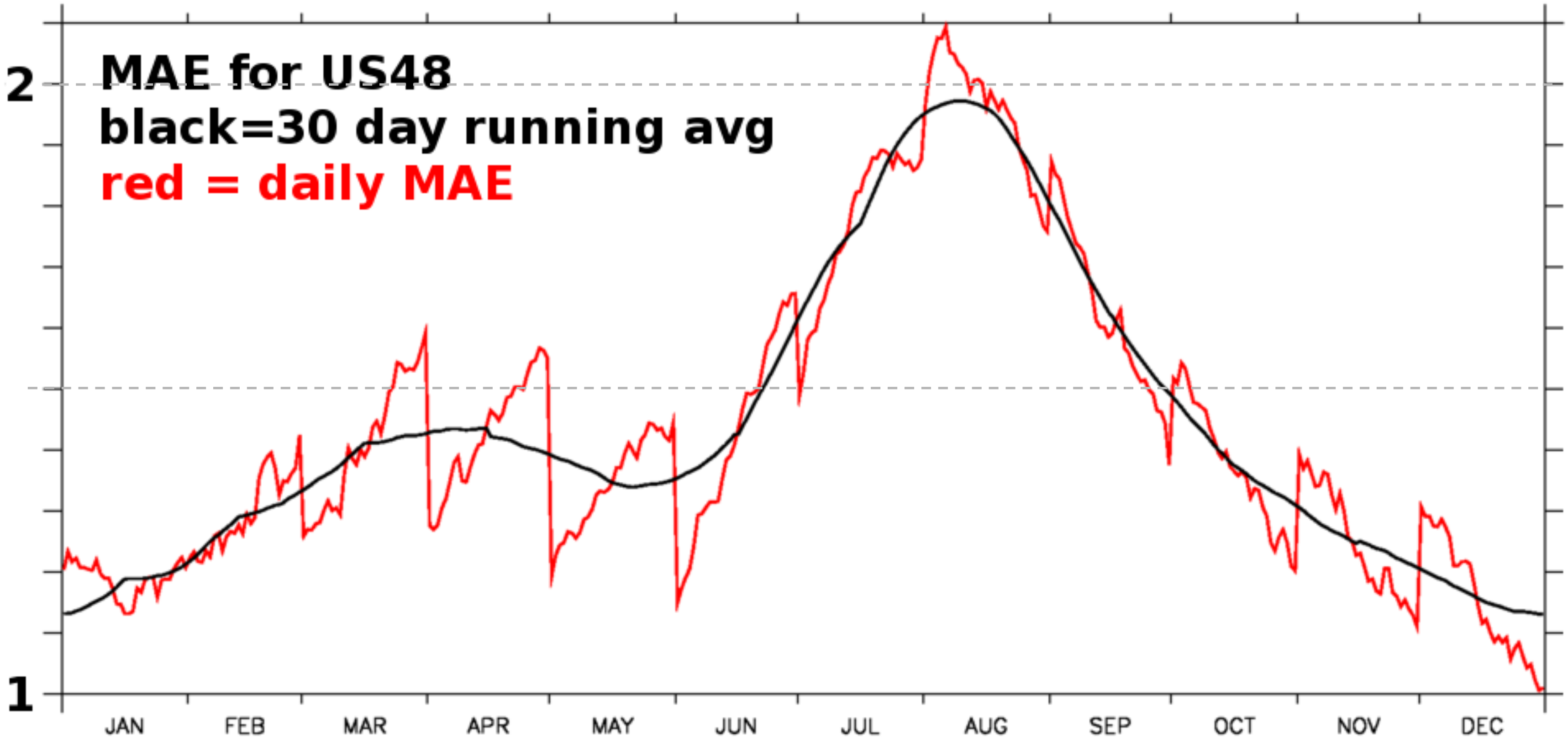
ARRM method
31-day running mean MAE ratios
tasmax = daily max Temp @ 2m



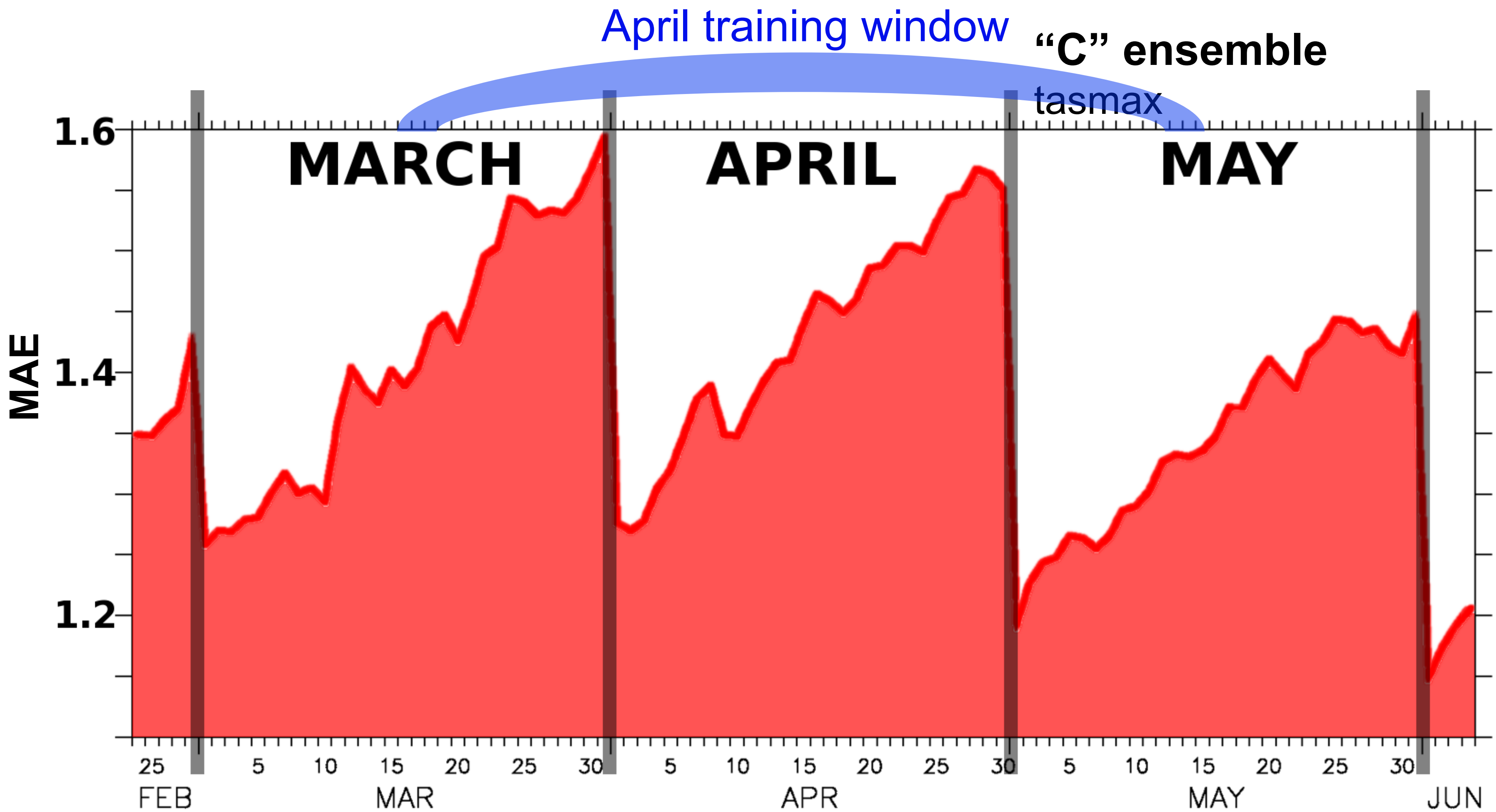
If and when ratio=1.0, the stationarity assumption fully holds
(*i.e.,* no degradation in mean absolute downscaling error
during 2085-2095 vs. the 1979-2008 period using in training.)

Looking at how well the stationarity assumption holds in different seasons

“C” ensemble
tasmax

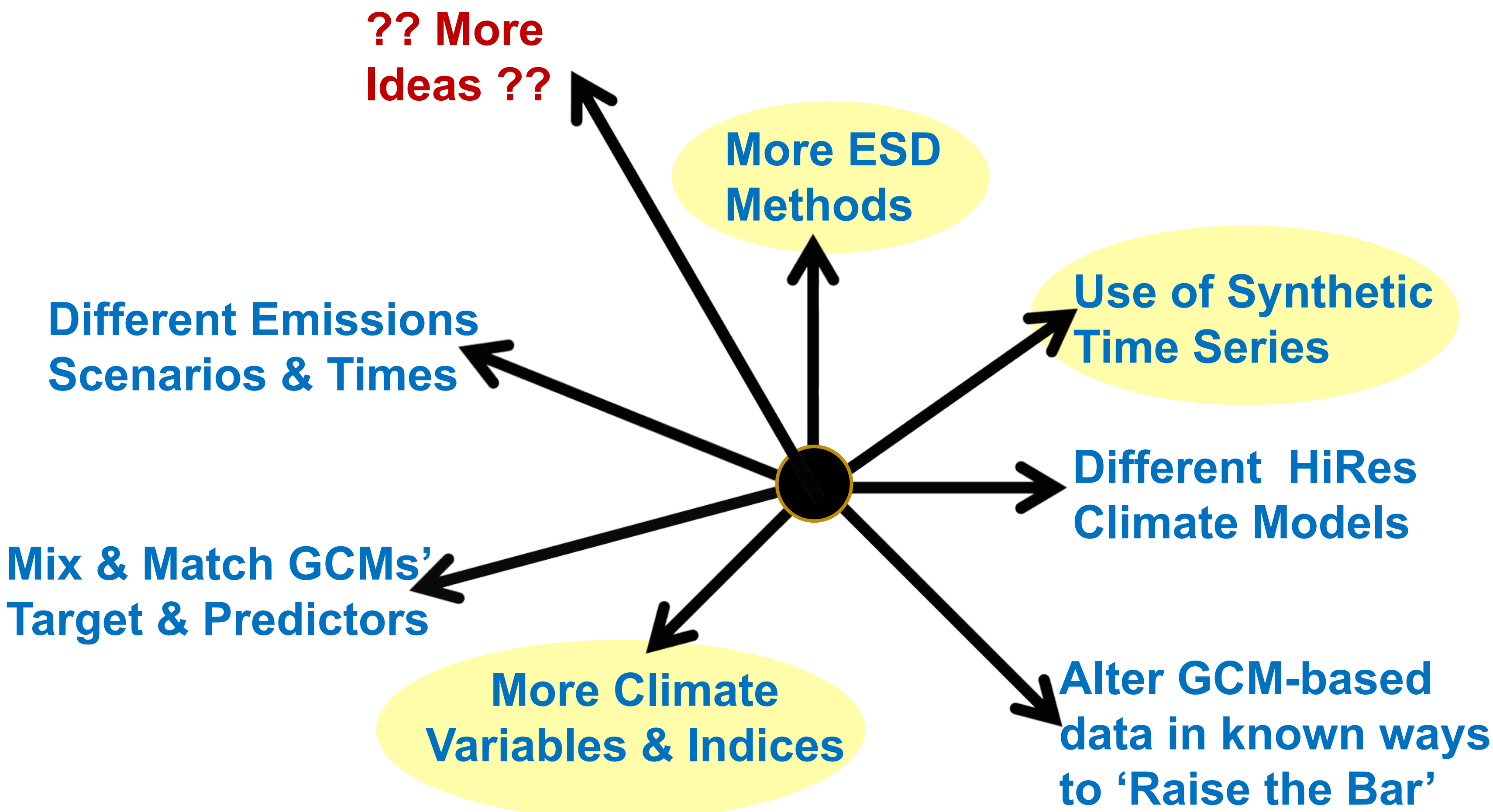


A clear intra-month MAE trend in some but not all months



"sawtooth" has smaller errors in the cooler part of the month –and- larger errors in the warmer part of month, when applied to end of 21st century projections

Options for extending this 'perfect model-based' exploration of statistical downscaling stationarity



Goals of this presentation

1. Define the ‘stationarity assumption’ inherent to statistical downscaling future climate projections.
2. Present our ‘perfect model’ (aka ‘big brother’) approach to quantitatively assess the extent to which the stationarity assumption holds.
3. Illustrate with a few examples the kind of results one can generate using this evaluation framework
4. Introduce approaches to extend and supplement the method (setting the hurdle at different heights).
5. Invite statistical downscalers to consider testing their methods within the perfect model framework.

www.gfdl.noaa.gov/esd

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